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PROGRAM ALPHAPRINT FOR THE PROCESSING OF DATA ACQUIRED BY AN ALPHANUCLEAR LTD. LOGGER SYSTEM

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PROGRAM ALPHAPRINT FOR THE PROCESSING OF DATA ACQUIRED BY AN ALPHANUCLEAR LTD. LOGGER SYSTEM

by

M. Grenier*

ABSTRACT

The program ALPHAPRINT described in this report is used to process data that is acquired by a data logging system developed by AlphaNUCLEAR Ltd., Canada. The software allows the transformation of counts per hour from radon gas probes to pCi/L of radon using calibration factors determined elsewhere. Analog probes (e.g., temperature, atmospheric pressure) voltages are numerically transformed into more manageable physical units. ALPHAPRINT also creates plot files that are compatible with Appleplot software. ALPHAPRINT is written in Applesoft BASIC. A listing of the program and a comprehensive description of same are included.

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PROGRAMME ALPHAPRINT POUR LE TRAITEMENT DES DONNÉES ACQUISES PAR UN SYSTÈME D'ENREGISTREMENT ALPHANUCLEAR LTD.

par

M. Grenier*

RÉSUMÉ

Le présent rapport contient une description du programme ALPHAPRINT qui est utilisé pour le traitement des données acquises par un système d'enregistrement mis au point par la AlphaNUCLEAR Ltd., Canada. Le logiciel permet la transformation du compte par heure des sondes au radon en pCi/L de radon à l'aide de facteurs d'étalonnage déterminés ailleurs. Des sondes analogues (e.g., température, pression atmosphérique, tension) sont transformés numériquement en unités physiques plus facilement maniables. Le programme ALPHAPRINT est écrit en langage BASIC Applesoft. Le rapport présente également le répertoire et une description complète du programme.

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INTRODUCTION

This report describes a program (ALPHAPRINT) that is used in conjunction with a data logging system designed by AlphaNUCLEAR Ltd., Mississauga, Ontario. The logger can accomodate up to ten digital devices such as passive radon gas monitors or alpha-meters (AM) as they are commonly called. Seven ports are also available to accomodate analog devices (AD) such as soil or air temperature probes, barometric pressure and relative humidity sensors. These probes or sensors have been available as off the shelf items for a number of years. Until recently, the most convenient way of obtaining a hard copy of the data was to make use of the data logger printer. One of the disadvantages of using the system's printer is that field conditions such as low temperatures, and environmental contaminants such as sand and dust have often been the cause of mechanical printer failure and loss of data.

In order to prevent such losses, AlphaNUCLEAR has developed the Non-Volatile Mass Storage System (NVMSS model 610). The system is presently in use at the Elliot Lake Laboratory in conjunction with Apple and Apple compatible hardware and software to dump logger data from the NVMSS into a sequential data file with the help of an Apple II plus microcomputer. The program ALPHAPRINT is then used to operate on this file. This program, as well as printing the data stored into the sequential file (this could be easily performed using VISITERM software), also performs tedious calculations such as applying AM calibration factors to convert counts per hour (cphr) as collected by the logger to pCi/L of radon gas. The program also calculates the average count rate (cphr) and the average radon gas concentration in pCi/L for each AM over the entire time period during which data was being stored. Conversion of analog device voltages into more meaningful and manageable physical units such as degrees Celsius, millibars of pressure and percentage

relative humidity are also being applied for each AD probe. The program also builds sequential files that may be used in conjunction with Appleplot software to plot cphr, pCi/L, relative humidity (RH), pressure (P) and temperature (T) as a function of time on an hourly basis for periods of up to ten days.

In order to appreciate the ALPHAPRINT program, it is necessary to be able to visualize the entire logger/computer system, to know how it is deployed in the field and to understand the data dumping procedures that take place at the laboratory.

DESCRIPTION OF THE SYSTEM

Prior to the NVMS system being put on the market, a typical logger system would consist of the data logger unit which could accommodate up to seven analog (AD ports) and up to ten digital (AM ports) devices. For the purpose of illustration, the analog devices could be an air temperature probe, an atmospheric pressure and a relative humidity sensor in AD ports one, two and three respectively. Four passive radon gas monitors (AMs) are connected to the first four AM ports. This hypothetical set-up is shown in Fig. 1. In this configuration, data can be obtained from the thermal printer built into the data logger. Figure 2 shows a typical block of data that could be obtained from the data logger printer. The time and date are displayed on the first two lines. The next four lines show the counts per hour (cphr) for each of the four digital devices. The next seven lines show the voltages at each of the seven analog ports. Notice that according to the configuration described above, only ports one, two and three show voltages different from 00.01 VDC. Finally, the last line shows the status of the power unit that supplies the data logger system (typically around 24 VDC). Such data blocks were printed hourly (or at regular intervals) for days.

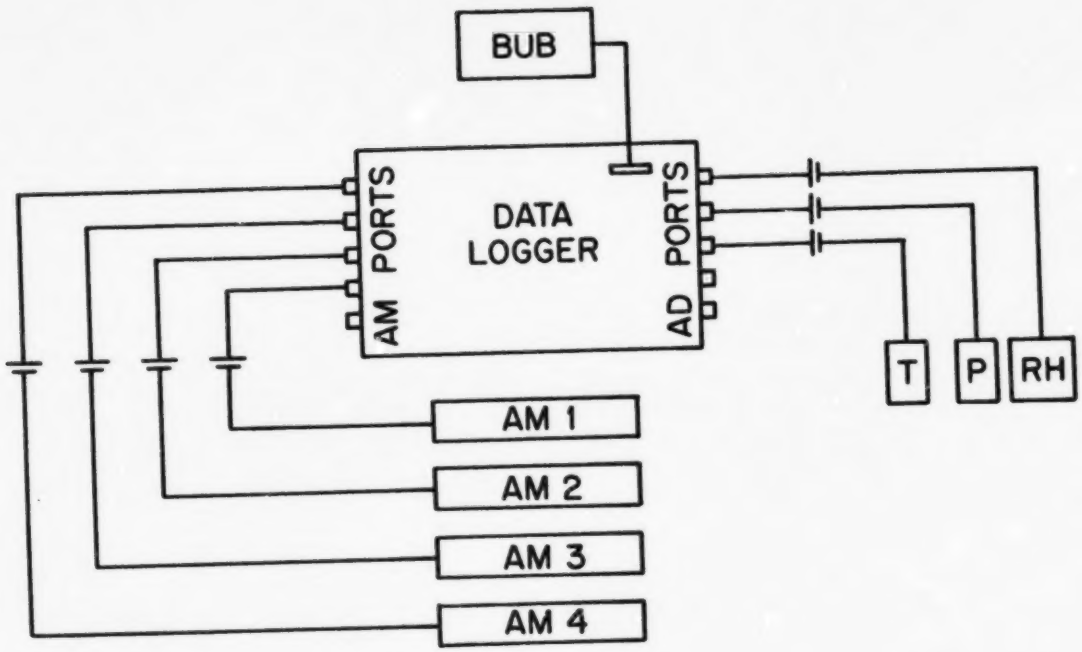

Fig. 1 - Typical field logger unit. AM ports can accomodate up to 10 alpha-meter probes. AD ports can have up to 7 digital inputs; in this case one temperature (T), one pressure (P) and one relative humidity (RH) probe are shown. The bubble memory (BUE) is connected to an RS-232 data transfer port.

```
TIME 145000
DATE    152

AM 1    193
AM 2    178
AM 3    166
AM 4    157

AD 1  02.23
AD 2  07.34
AD 3  06.08
AD 4  00.01
AD 5  00.01
AD 6  00.01
AD 7  00.01
BAT   23.73
```

Fig 2 - Typical block of data as it would appear on the printer. On Julian date 152 at 14:50:00 the cphr values for AM probes 1 through 4 were 193, 178, 166 and 157, respectively. The voltage at the temperature probe (AD 1) is 2.23, it is 7.34 and 6.08 for the pressure (AD 2) and relative humidity (AD 3) sensors. AD ports 4 to 7 are free and the power supply voltage is 23.73 VDC.

When the NVMSS became available, it provided a good alternative to the data logger printer, especially in harsh environmental conditions. Time saving with respect to changing printer paper and printer maintenance is quite substantial. More importantly, the system now allows the user to manipulate the mass of data with the help of a microcomputer. A typical NVMS system consists of two bubble memory modules (BUB) for data storage, one AC line power supply/interface (INT), and a cable to connect a BUB to the RS-232 data transfer port on the data logger's console.

In a typical field use the data logger system would be deployed as in Fig. 1, with the BUB connected as shown. Then, at regular intervals (weekly), the blank BUB is substituted for the one on the logger which has been storing data blocks (as in Fig. 2) for seven days. The full BUB is then brought back to the laboratory for the data to be dumped into the microcomputer and processed (Fig. 3). In order to dump from the BUB, the computer has to be made into a passive terminal. To implement this, a California Computer Systems Apple II Asynchronous Serial Interface Card (model 7710A), and a suitably altered Visiterm Software package (Visicorp, CA) were supplied by AlphaNUCLEAR. The interface card is used to couple the AC power/interface (INT) to the computer as shown in Fig. 3. With the Visiterm Software in disk drive No. 1 (D1, see Fig. 3), and a diskette with the ALPHAPRINT program in D2, the BUB containing the data of interest is connected to the computer via the INT. All the data blocks stored in the BUB may then be stored sequentially into a file called Alphalogger 1 in the diskette in D2. When the dumping operation is completed the BUB may be erased for later use. The ALPHAPRINT diskette (which now also contains the data file Alphalogger 1) is moved to D1, and a diskette containing the Appleplot Software is placed in D2 where the sequential plot files created by ALPHAPRINT will be stored.

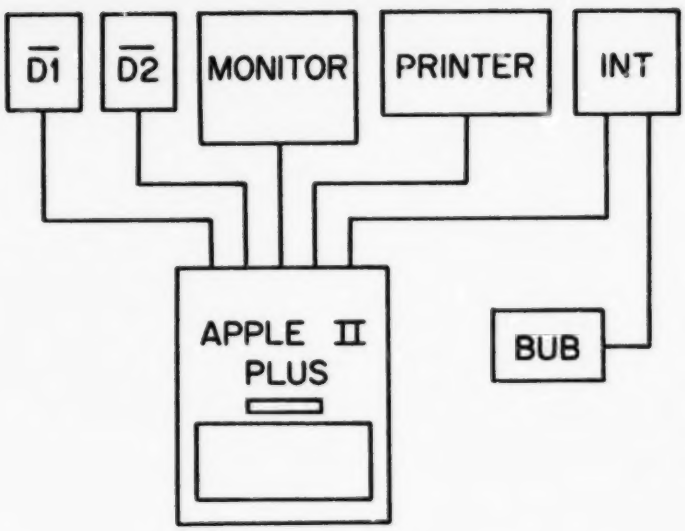

Fig. 3 - Configuration of Apple II plus system needed to dump the contents of the bubble memory (BUB) into a file created in disk No. 2 (D2). The power supply/interface (INT) is used to couple the BUB to the interface card inside the Apple computer.

DESCRIPTION OF PROGRAM ALPHAPRINT

The ALPHAPRINT program is meant to process the analog and digital data from the data logger. ALPHAPRINT does not require extensive computer knowledge on the part of the user and also some checks are incorporated to ensure that processing is not stopped due to erroneous data produced during the dumping procedure. The program listing and a comprehensive description of the program can be found in Appendix A and B, respectively.

A simplified flow chart of ALPHAPRINT is shown in Fig. 4a and 4b. First, some input variables are entered (date, sampling place, comments), then the user is asked to input the number of radon gas monitors (AMs) connected to the AM ports of the data logger, and whether or not the user wishes to input calibration factors for each AM probe. There are two calibration factors per probe, the A and the B factor. The B factor is the number of counts due to long term contamination, i.e., background counts in a one hour period that should be subtracted from the cphr figure from the logger data. The A factor converts the corrected cphr figures into picoCuries per litre of radon gas (pCi/L). Therefore, pCi/L figures for each AM probe are obtained using Equation 1.

$$[Rn]pCi/L = A \times (cphr - B) \qquad \text{Eq 1}$$

If the calibration factors are not entered by the user, default values of zero and one will be assigned to all B's and A's, respectively.

The user is then shown a default assignment of analog probes to AD ports on the logger and is asked to input a different assignment scheme if he so wishes. The program then proceeds to print the input data, the AM calibration factors and the AD probe assignment order as chosen by the user.

The user may now initiate the retrieval of data from the file Alphalogger 1 stored previously in the diskette presently being used. Control

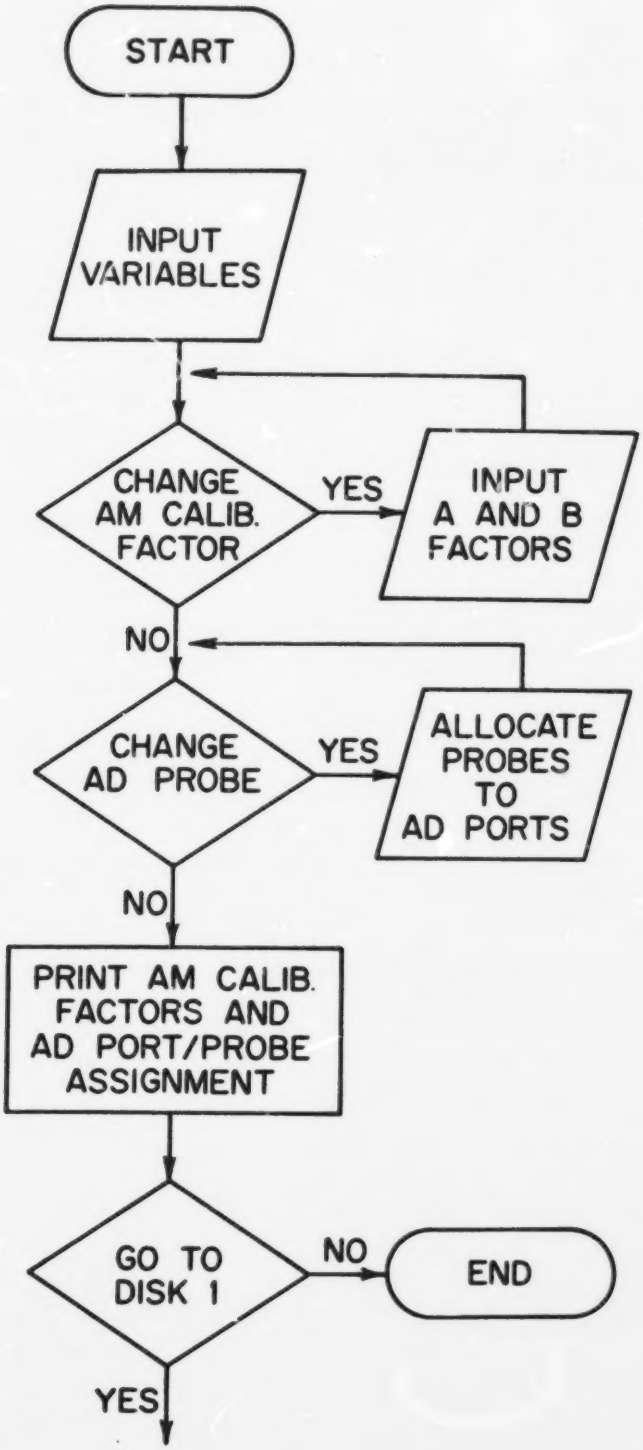

Fig. 4a - ALPHAPRINT program flow chart.

Cont. overleaf

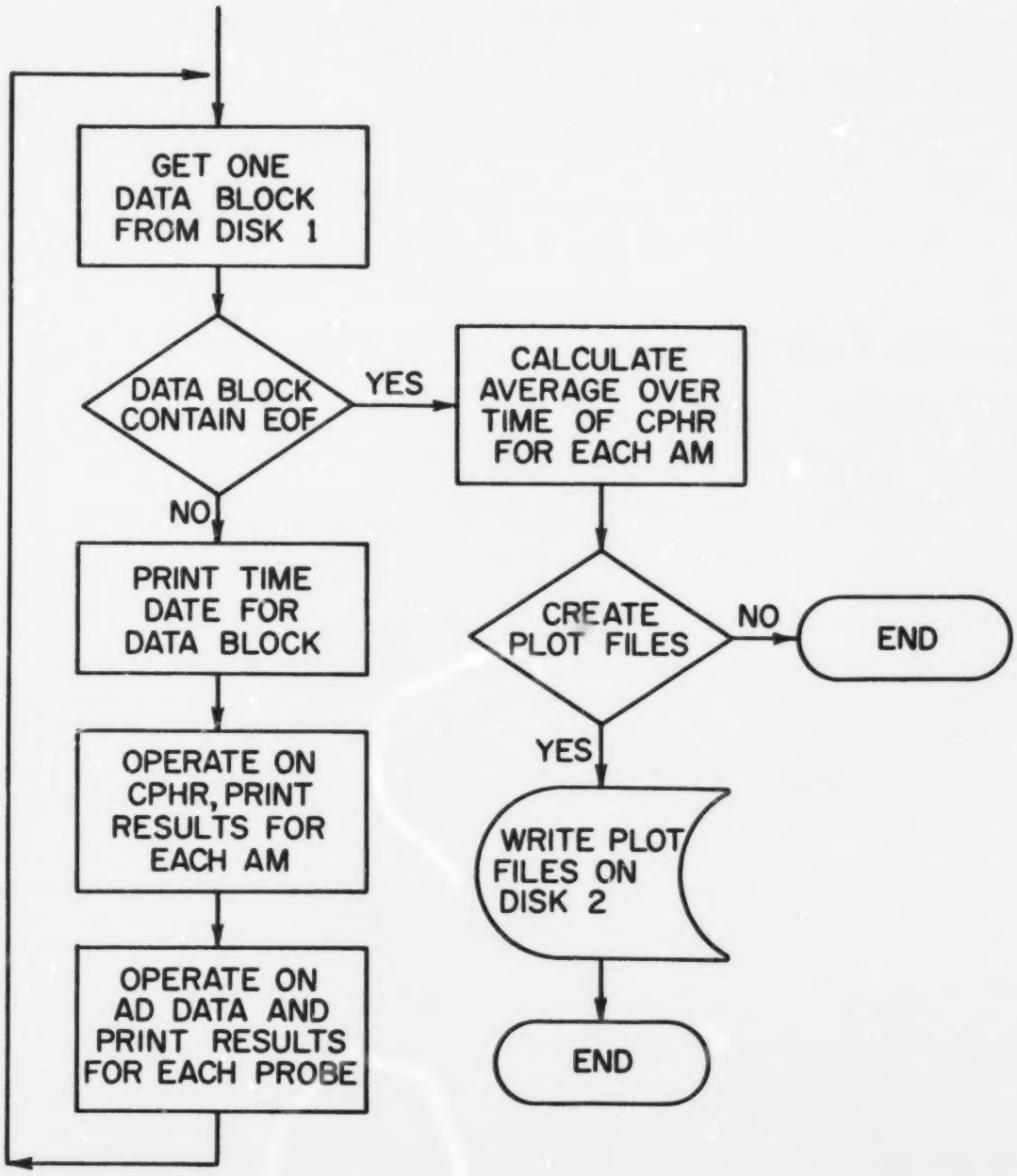
GET ONE DATA BLOCK FROM DISK 1
DATA BLOCK CONTAIN EOF
YES
CALCULATE AVERAGE OVER TIME OF CPHR FOR EACH AM
NO
PRINT TIME DATE FOR DATA BLOCK
CREATE PLOT FILES
NO
END
YES
OPERATE ON CPHR, PRINT RESULTS FOR EACH AM
WRITE PLOT FILES ON DISK 2
OPERATE ON AD DATA AND PRINT RESULTS FOR EACH PROBE
END

Fig. 4b - ALPHAPRINT program flow chart
cont. from Fig. 4a.

of the program is sent to D1 to get the first data block (a normal data block should be identical in form to that shown in Fig. 2). If the first line of the data block reads END OF FILE, then the average over time for each AM is calculated and printed and plot files are created upon user's request. The program then ends automatically. If the END OF FILE marker is not found, the time and date on which this data block was obtained are printed. The cphr figures for each AM probe is then converted to pCi/L of radon gas, using the A and B calibration factors mentioned above and Equation 1. These results are printed also.

Voltages from the different AD probes now have to be transformed to other physical units. The conversion to degrees Celsius for the air temperature probe is easily implemented. The probe operates in two temperature ranges; the high range for temperatures between 0°C and 60°C and the low range for temperatures between -40°C and 20°C. These ranges are preselected by using a switch located on the probe itself. When the air temperature probe is in the high range the voltage value needs to be multiplied by ten to yield degrees Celsius. If the probe is in the low range, the voltage is multiplied by ten and to this value we subtract 40 to obtain degrees Celsius. The soil temperature probe voltage is converted to degrees Celsius by multiplying by 10 and subtracting 30. The above transformations are done according to calibration data for the probes.

The atmospheric pressure probe voltage is converted to millimetres of mercury (mm Hg) by multiplying the probe voltage by 100. The program will also yield the pressure in millibars by dividing the mm Hg value by .75. The pressure reading may then be approximately converted (this is not performed by ALPHAPRINT) to sea level values by applying a form of the hydrostatic equation (Eq 2 from ref 1). This formula uses a mean value for the air temperature of the layer of air between the point of measurement and sea level.

$$\ln(P_o/P) = g(Z - Z_o)RT \qquad \text{Eq 2}$$

where, p_o is the atmospheric pressure at height Z_o

p is the atmospheric pressure at height Z

g is the gravitational constant (981 $cm.s^{-2}$)

R is the gas constant for air ($2.87x10^6$ cm^2s^{-2} deg^{-1})

T is the mean temperature of the air layer (deg. Kelvin)

The conversion from voltage to relative humidity is more tedious. According to AlphaNUCLEAR (2) the temperature of the cell (T_C) that measures dew point (probe manufactured by YSI, U.S.A.) may be obtained by subtracting five from the RH probe voltage (V_p) value and multiplying this new value by fifty. YSI then lists (3) a table to help convert T_C to dew point temperature (T_D). Table 1 lists some of these values in the appropriate range. Numerically, it is a simple task to convert the probe voltage (V_p), obtained from the logger, to dew point temperatures. Figure 5 shows a graph (T_D versus V_p) that was obtained using the data from Table 1. Assuming a linear relationship T_D may be inferred from Equation 3 which was obtained by linear regression.

$$T_D = 35.5\ V_p - 202.9 \qquad \text{Eq 3}$$

If one now obtains the ambient temperature (T_A) (available from the temperature probe), the relative humidity may then be calculated as the ratio of pressure of water vapour over water at temperature T_D (v_D) to that at temperature T_A (v_A). To obtain the pressure of vapour over water as a function of temperature one may consult reference 4. Table 2 lists some of those vapour pressures as a function of temperature as well as the natural logarithm of vapour pressure in an appropriate range. If one plots the natural logarithm of vapour pressure as a function of temperature (Fig. 6), simple linear regression shows that:

$$\ln(v) = .067T + 1.503 \qquad \text{Eq 4a}$$

Table 1 - Table showing relative humidity probe voltage and corresponding cell temperature (T_C) and dew point temperature (T_D). From references 2 and 3.

V_p (Volts DC)	T_C (°C)	T_D (°C)
4.61	-19.52	-40
4.89	-5.46	-30
5.17	8.37	-20
5.44	21.92	-10
5.71	35.25	0
5.97	48.52	10
6.26	63.09	20
6.56	79.16	30
6.88	94.11	40
7.14	106.82	50
7.39	119.50	60

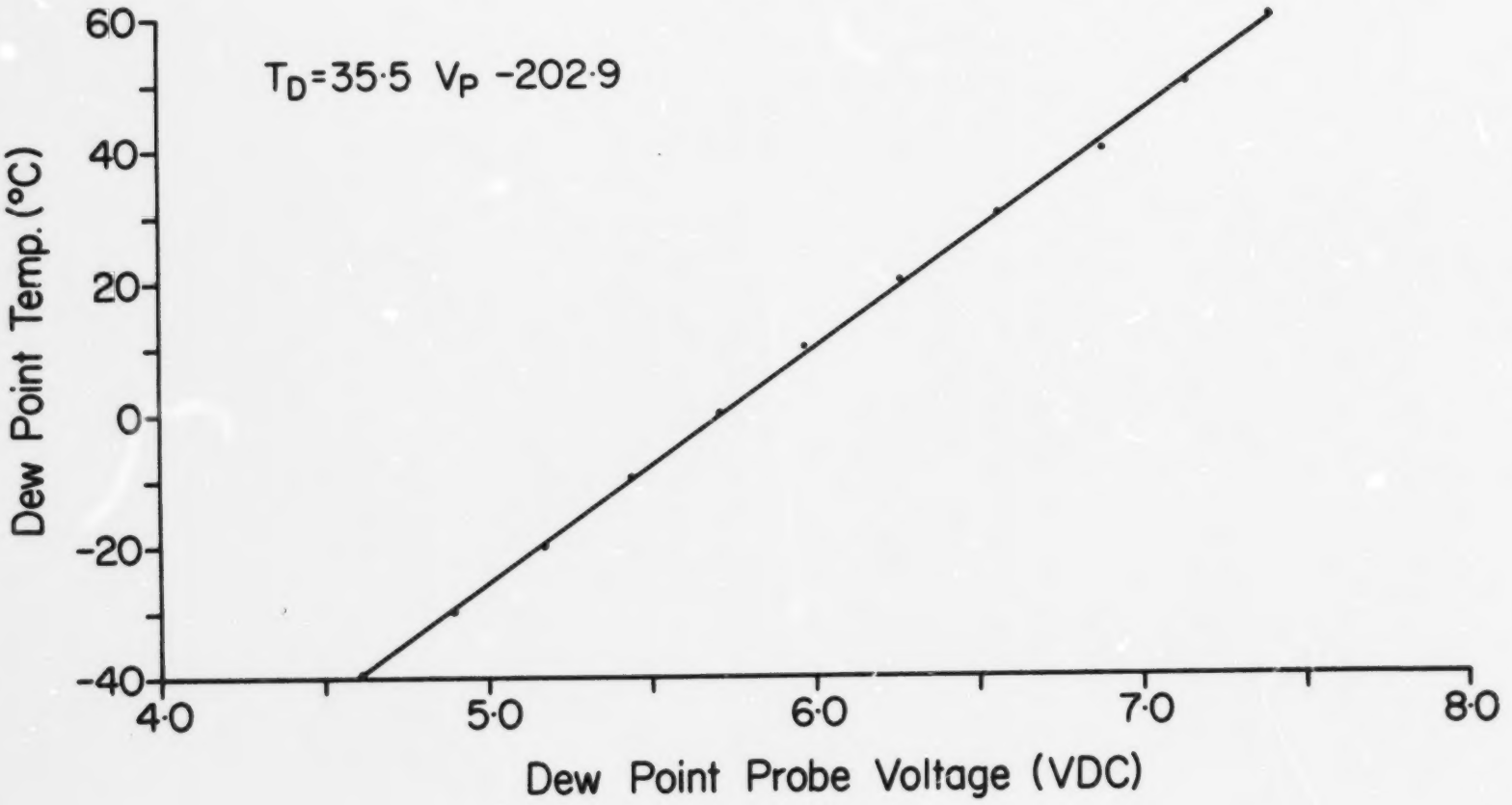

Fig. 5 - Dew point temperature versus probe voltage for relative humidity probe. Data from Table 1.

Table 2 - List of theoretical vapour pressure over water and natural logarithm of same as a function of temperature. From ref. 4.

T (°C)	v (mm Hg)	ln(v)
-10	2.15	.76
-5	3.16	1.15
0	4.58	1.52
5	6.54	1.88
10	9.21	2.22
15	12.79	2.55
20	17.54	2.86
25	23.76	3.17
30	31.82	3.46

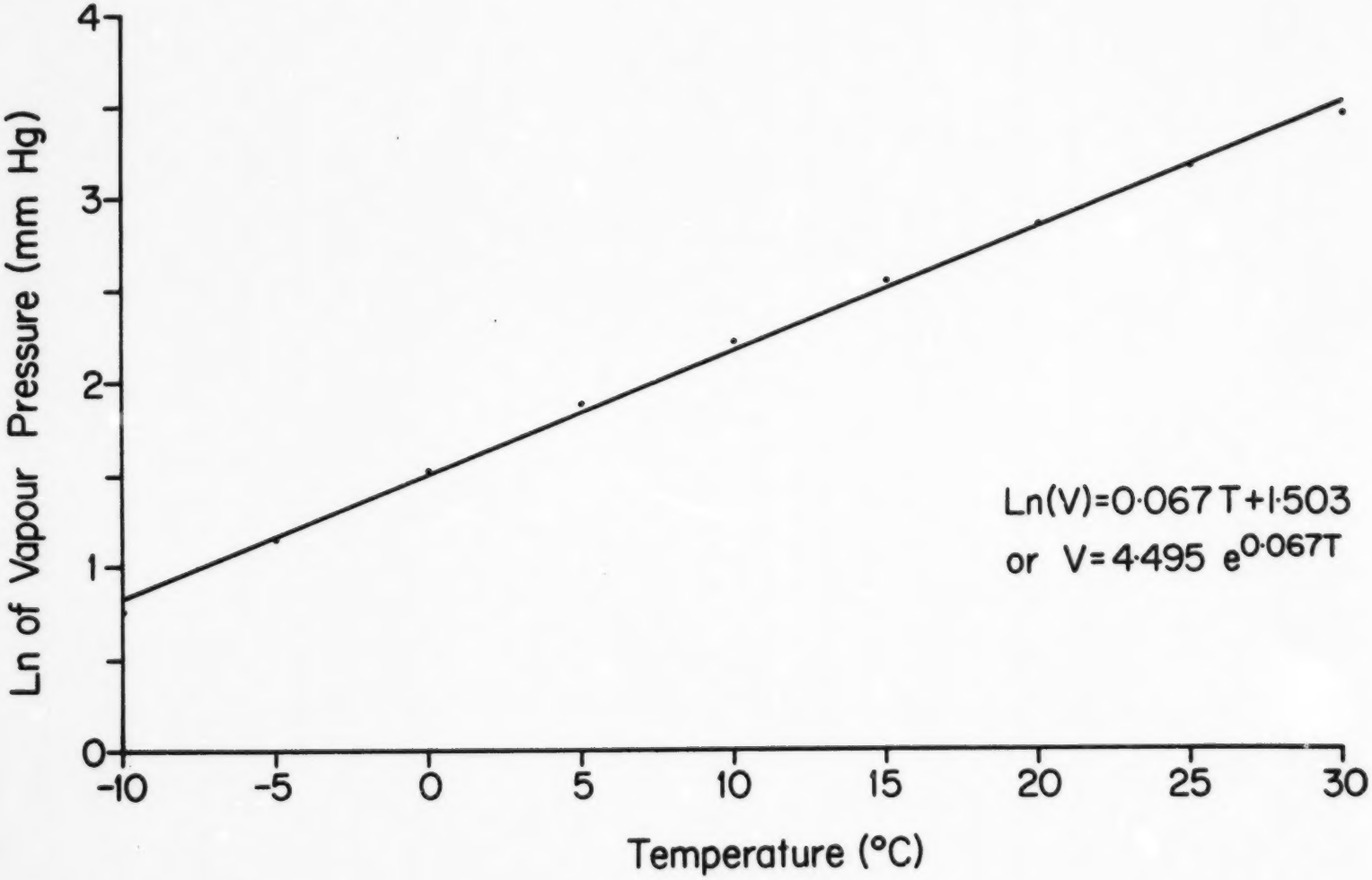

Fig. 6 - Natural logarithm of vapour pressure versus temperature.
Data from Table 2.

or, $v = 4.495\exp(.067T)$ Eq 4b

Using Equation 4b, the relative humidity may be obtained by dividing v_D by v_A and multiplying by 100. All of the above procedures have been implemented numerically and are used by ALPHAPRINT to convert AD voltages into other physical units. Once these conversions have been made (refer back to Fig. 4b) the AD probe voltages and the converted results are printed along with the voltage of the logger's power unit at the time of data acquisition. Figure 7 shows the sample print-out that would be associated with the data block from Fig. 2. Every time the algorithm is through processing a data block, the pCi/L value for every AM, the average pCi/L and cphr for that block (from all AM probes), the temperature, the pressure and all of the parameters calculated are stored in special arrays that will be used to store plotting data in D2. Figure 8 is a sample reproduction of a plot as it would look as produced by the Appleplot Software. Control of the program is then sent back to the point where another data block is retrieved from the data file. The steps described above are repeated until the END OF FILE marker is found.

IMPROVEMENT OF ALPHAPRINT PROGRAM

A new version of ALPHAPRINT is presently under development. A few refinements will be added, but the major feature of this new version will be centred around the interfacing of two commercially available condensation nuclei counters to the AlphaNUCLEAR data logger and the processing of voltages into aerosol concentration figures (particles per cubic cm). This new version of ALPHAPRINT will be presented in a forthcoming report.

ACKNOWLEDGEMENTS

Dr. J. Bigu acted as Scientific Authority in the development of the AlphaNUCLEAR data acquisition system.

TIME 145000			AVERAGE	
DATE	152	PCI/L	COUNTS	PCI/L
AM 1	193	214.5		
AM 2	178	192.2		
AM 3	166	196.35		
AM 4	157	163.2	173.5	191.56
AD 1	02.23	22.3	DEG. CELCIUS	
AD 2	07.34	734 MMHG	976.22 MBAR	
AD 3	06.08	53.45	% REL HUM	
BAT	23.73			

Fig. 7 - Typical sample ALPHAPRINT print-out using data shown in Fig. 2.

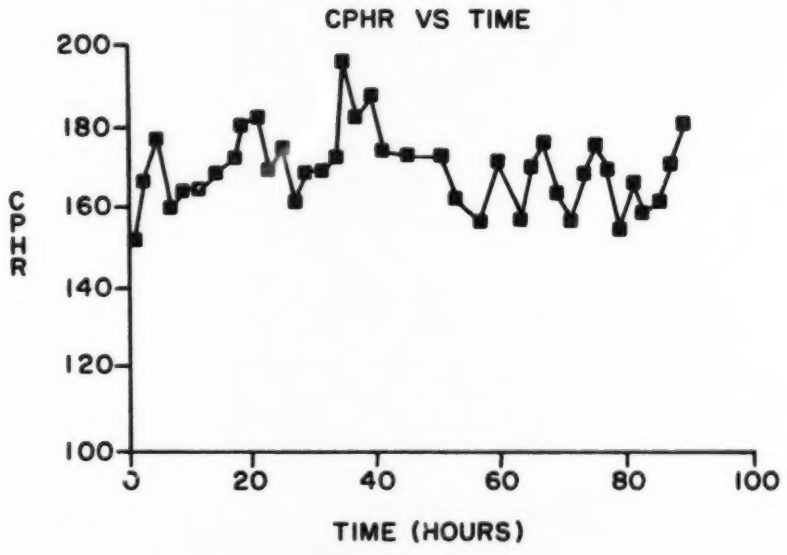

Fig. 8 - Counts per hour versus time, a sample reproduction of this plot as it would be produced by the Appleplot software.

REFERENCES

1. Longley, R.W., "Elements of meteorology"; John Wiley and Sons Inc., New York; 1970.

2. AlphaNUCLEAR, "Dew point instrument instruction manual".

3. YSI, "Model 940 Dew point sensor instruction manual".

4. CRC, "Handbook of chemistry and physics"; 49th edition, Weast, R.C. (Ed.); The Chemical Rubber Company, Cleveland, Ohio; 1968

APPENDIX A

```
100  REM
110  REM
120  REM
130  REM  ************************
140  REM  *                      *
150  REM  * PROGRAM ALPHAPRINT   *
160  REM  * WRITTEN JUNE  1984   *
170  REM  * MICHEL G GRENIER     *
180  REM  *                      *
190  REM  * THIS PROGRAM PRINTS  *
200  REM  * AND PROCESSES DATA   *
210  REM  * FROM THE FILE ALPHA-*
220  REM  * LOGGER 1 FOUND ON    *
230  REM  * THE SAME DISKETTE .  *
240  REM  *                      *
250  REM  * IT ALSO CREATES      *
260  REM  * FILES ON A DISKETTE  *
270  REM  * PLACED IN DRIVE 2    *
280  REM  * THESE FILES MAY      *
290  REM  * THEN BE PLOTTED IF   *
300  REM  * IF THE DISKETTE IN   *
310  REM  * DRIVE 2 CONTAINS THE*
320  REM  * APPLEPLOT (C) SOFT-  *
330  REM  * WARE .               *
340  REM  *                      *
350  REM  ************************
360  REM
370  REM
380  REM
390  REM  ************************
```

```
400  REM  *  LIST OF VARIABLES  *
410  REM  ************************
420  REM
430  REM  A(I) VECTOR VARIABLE, K
     EEPS ALPHAMETER CALBRATION F
     ACTORS (PCI/L/CPHR) FOR EACH
      AM.
440  REM  AC(I) VECTOR VARIABLE,
     KEEPS A CODE NUMBER FOR EACH
      ANALOG DEVICE (AD). THIS DE
     TERMINES WHAT EACH AD IS.
450  REM  AD$(I) CHARACTER ARRAY,
      ACCEPTS AD'S DATA FROM DISK
     ETTE DATA FILE
460  REM  AG(I) PLOTTING FILE VEC
     TOR,CPHR
470  REM  AM(I) VECTOR VARIABLE,
     KEEPS NUMERIC PORTION OF AM$
     (I).
480  REM  AP(I) PLOTTING FILE VEC
     TOR, PCI/L
490  REM  AM$(I) CHAR ARRAY, ACCE
     PTS ALPHAMETER DATA FROM DIS
     K DATA FILE
500  REM  B(I) VECTOR VARIABLE, K
     EEPS ALPHAMETER BACKGROUND C
     ALIBRATION FACTOR (CPHR) FOR
      EACH AM.
510  REM  CG(I) VECTOR VARIABLE,
     KEEPS AVERAGE FOR EACH ALPHA
     METER OF ALL CPHR RECORD.
520  REM  CM$ STRING VARIABLE, KE
     EPS COMMENT
530  REM  D$ CHARACTER VARIABLE E
     QUAL TO CTRL-D, DATA FILE CO
     NTROL CHARACTER
540  REM  DT$ STRING VARIABLE, KE
     EPS DATE
550  REM  DY$ DUMMY SRTING VARIAB
     LE
560  REM  E$(I) CHARACTER ARRAY,
     ACCEPTS DATE, TIME AND A BLA
     NK LINE FROM DATA FILE
570  REM  E1 NUMERIC VARIABLE, KE
     EPS ATMOSPHERIC VAPOR PRESSU
     RE AT TEMPERATURE TM OR AMBI
     ENT.
580  REM  E2 NUMERIC VARIABLE, KE
     EPS ATMOSPHERIC VAPOR PRESSU
     RE AT TEMPERATURE T1 OR DEW
     POINT.
```

```
590  REM  FN DP(X) FUNCTION USED
     TO ROUND OF VARIABLES TO 2 D
     ECIMAL PLACES
600  REM  GA TEMPORARY VARIABLE E
     QUAL TO AC(I)
610  REM  GA(I) ADDER, KEEPS RUNN
     ING TOTAL OF INDIVIDUAL AM'S
     . LATER IS DIVIDED BY TOTAL
     NUMBER OF RECORDS TO GET AVE
     RAGE CPHR FOR EACH AM'S.
620  REM  GP(I) SAME AS GA(I), BU
     T FOR PCI/L VERSION OF AM DA
     TA.
630  REM  I FOR LOOP INCREMENTAL
     INDEX
640  REM  IX NUMERIC VARIABLE, RE
     LATED TO AD PROBES NO. (1-7)

650  REM  IX$ CHARACTER STRING ,R
     ELATED TO TYPE OF AD PROBE (
     A-F)
660  REM  NN NUMERICAL VARIABLE,
     KEEPS TOTAL NUMBER OF RECORD
     S
670  REM  NS NUMERICAL VARIABLE,
     KEEPS NUMBER OF ALPHAMETER P
     ROBES.
680  REM  NU VARIABLE EQUAL TO NU
     MERICAL PORTION OF AD$(I) ,
     I.E. ANALOG DEVICE NUMERICAL
      VALUE.
690  REM  PC(I) VECTOR VARIABLE,
     KEEPS PCI/L VERSION OF CPHR
     RECORDS FOR EACH AM.
700  REM  PR NUMERICAL VARIABLE,
     PRESSURE  MMHG
710  REM  PG(I) SAME AS CG(I), US
     ED FOR PCI/L DATA
720  REM  RH NUMERICAL VARIABLE,
     RELATIVE HUMIDITY, %
730  REM    RH(I) PLOTTING FILE V
     ECTOR, RELATIVE HUMIDITY ,%
740  REM  RR NUMERICAL VARIABLE,
     PRESSURE  MBARS.
750  REM  RR(I) PLOTTING FILE VEC
     TOR, PRESSURE MBARS
760  REM  SP$ SAME AS AD$(I) WITH
      FIRST DATA RECORD REMOVED.
770  REM  SS STEP PARAMETER FOR F
     OR LOOP
780  REM  ST$ STRING VARIABLE, KE
     EPS SAMPLING PLACE
790  REM  TA NUMERICAL VARIABLE,
     CPHR ADDER
```

```
800  REM  TM NUMERICAL VARIABLE,
     TEMPERATURE DEGREE CELCIUS
810  REM  TP NUMERICAL VARIABLE,
     PCI/L ADDER
820  REM  TA(I) VECTOR VARIABLE,
     KEEPS AVERAGES OF CPHR FOR E
     ACH RECORD
830  REM  TH(I) PLOTTING FILE VEC
     TOR, TEMPERATURE-HI
840  REM  TL(I) PLOTTING FILE VEC
     TOR, TEMPERATURE-LO
850  REM  TP(I) SAME AS TH(I) FOR
      PCI/L
860  REM  TS(I) PLOTTING FILE VEC
     TOR, SOIL TEMPERATURE DEG CE
     LCIUS.
870  REM  T1 NUMERICAL VARIABLE,
     DEW POINT TEMPERATURE DEG. C
     ELCIUS.
880  REM  TS NUMERICAL VARIABLE,
     SOIL PROBE TEMPERATURE, DEG.
      CELCIUS.
890  REM  X DUMMY VARIABLE
900  REM  Y$ YES OR NO INPUT STRI
     NG
910  REM  ZZ$ EMPTY STRING
920  REM
930  REM
940  REM
950  REM  THE FOLLOWING SECTION C
     ON-
960  REM  SISTS OF THE INITIALIZA
     TION
970  REM  PORTION OF THE PROGRAM.

980  REM  THIS INCLUDES DIMENTION
     ING OF
990  REM  OF ARRAYS AND VECTORS A
     S WELL
1000  REM  INPUTTING OF NECESSARY
      VARIA
1010  REM  BLES.
1020  REM
1030  REM
1040  REM
1050  DIM AG(250): DIM AP(250): DIM
     TH(250): DIM TL(250): DIM RR
     (250): DIM RH(250): DIM TS(2
     50)
1060  DEF  FN DP(X) =  INT (X * 1
     00 + .5) / 100
1070  HOME : VTAB (10)
1080  INPUT "DATE ? ";DT$: HOME :
      VTAB (10)
```

```
1090  INPUT "SAMPLING PLACE ? ";S
      T$: HOME : VTAB (10)
1100  INPUT "COMMENT ? ";CM$: HOME
      : VTAB (10)
1110  INPUT "HOW MANY ALPHAMETERS
       ARE THERE ? ";NS: HOME : VTAB
      (10)
1120  FOR I = 1 TO NS:GA(I) = 0:G
      P(I) = 0: NEXT I
1130 NN = 0
1140  PRINT "INPUT ALPHAMETERS CA
      LIBRATION"
1150  PRINT "FACTORS A AND B, WHE
      RE B IS THE"
1160  PRINT "BACKGROUND OR CONTAM
      INATION"
1170  PRINT "PARAMETER AND A IS T
      HE TRUE"
1180  PRINT "CALIBRATION FACTOR I
      N PCI/L"
1190  PRINT "PER CPHR (HIT SPACE
      TO CONT)"
1200  GET DY$
1210  FOR I = 1 TO NS:A(I) = 1:B(
      I) = 0: NEXT I
1220  HOME : VTAB (8)
1230  PRINT "AM NO.","A FACT","B
      FACT": PRINT
1240  FOR I = 1 TO NS: PRINT I,A(
      I),B(I): NEXT I
1250  PRINT
1260  INPUT "DO YOU WISH TO CHANG
      E THE FACTORS (Y) OR (N) ? "
      ;Y$
1270  IF Y$ = "Y" THEN  GOSUB 235
      0: GOTO 1220
1280  HOME : VTAB (10)
1290  PRINT "THE FOLLOWING SECTIO
      N SETS"
1300  PRINT "THE USE OF EACH ANAL
      OG DE-"
1310  PRINT "VICE.TO DO THIS PLEA
      SE FOL-"
1320  PRINT "LOW INSTRUCTIONS."
1330  PRINT : PRINT "(HIT A SPACE
       TO CONTINUE)"
1340  GET DY$
1350 AC(1) = 1:AC(2) = 3:AC(3) =
      4:AC(4) = 5:AC(5) = 6:AC(6) =
      6:AC(7) = 6:AC(8) = 6
1360  HOME : VTAB (6)
1370  PRINT "AD NO.","PROBE"
1380  PRINT
1390  FOR I = 1 TO 7
```

```
1400 GA = AC(I): ON GA GOTO 1410,
     1420,1430,1440,1450,1460
1410  PRINT "AD ";I,"TEMP HI-SCAL
     E": GOTO 1470
1420  PRINT "AD ";I,"TEMP LO-SCAL
     E": GOTO 1470
1430  PRINT "AD ";I,"PRESSURE": GOTO
     1470
1440  PRINT "AD ";I,"REL. HUMIDIT
     Y": GOTO 1470
1450  PRINT "AD ";I,"SOIL TEMP.":
      GOTO 1470
1460  PRINT "AD ";I,"NONE": GOTO
     1470
1470  NEXT I
1480  PRINT : PRINT "DO YOU WISH
     TO CHANGE ANY OR"
1490  INPUT "ALL OF THESE (Y) OR
     (N) ? ";Y$
1500  IF Y$ = "Y" THEN  GOSUB 252
     0: GOTO 1360
1510  PR# 1: PRINT : PRINT DT$: PRINT
     ST$: PRINT CM$: PRINT
1520  PRINT "**********************
     ******************************
     **": PRINT
1530  PRINT "AM NO.","A FACT"," "
     ,"B FACT"
1540  PRINT " ","(PCI / L / CPHR)
     ","(CPHR)": PRINT
1550  FOR I = 1 TO NS
1560 ZZ$ = "   "
1570  PRINT I,A(I),ZZ$,B(I)
1580  NEXT I
1590  PRINT : PRINT "************
     ******************************
     **********"
1600  PRINT : PRINT "AD NO.","PRO
     BE": PRINT
1610  FOR I = 1 TO 7
1620 GA = AC(I): ON GA GOTO 1630,
     1640,1650,1660,1670,1680
1630  PRINT "AD ";I,"TEMP HI-SCAL
     E": GOTO 1690
1640  PRINT "AD ";I,"TEMP LO--SCAL
     E": GOTO 1690
1650  PRINT "AD ";I,"PRESSURE": GOTO
     1690
1660  PRINT "AD ";I,"REL. HUMIDIT
     Y": GOTO 1690
1670  PRINT "AD ";I,"SOIL TEMP.":
      GOTO 1690
1680  PRINT "AD ";I,"NONE": GOTO
     1690
```

```
1690  NEXT I
1700  PRINT : PRINT "************
      ****************************
      **********": PRINT "--------
      ----------------------------
      --------------"
1710  PRINT
1720  PR# 0
1730  REM
1740  REM
1750  REM
1760  REM  THIS NEXT SECTION GOES
      TO
1770  REM  THE DISKETTE TO GET TH
      E
1780  REM  DATA RECORDS AND WITH
      THE
1790  REM  HELP OF SUBROUTINES PR
      OCES-
1800  REM   SES THE DATA AND PRIN
      TS IT
1810  REM
1820  REM
1830  REM
1840  INPUT "READY TO GO TO DISK
      (Y) OR (N) ?";Y$
1850  IF Y$ = "N" THEN  END
1860  GOSUB 2800
1870  PR# 1
1880  PRINT
1890  FOR I = 1 TO 3
1900  IF  MID$ (E$(I),2,5) = "ATI
      ME" THEN  PRINT  MID$ (E$(I)
      ,3,16);"
                AVERAGE": GOTO 1940

1910  IF I = 1 THEN  PRINT  MID$
      (E$(I),2,15);"
                     AVERAGE": GOTO
      1940
1920  IF I = 2 THEN  PRINT  MID$
      (E$(I),2,15),"PCI/L","COUNTS
      ","PCI/L": GOTO 1940
1930  PRINT  MID$ (E$(I),2,15)
1940  NEXT I
1950  GOSUB 3080
1960  FOR I = 1 TO NS + 1
1970  IF I = NS + 1 THEN  PRINT :
      GOTO 2000
1980  IF I <  > 4 THEN  PRINT  MID$
      (AM$(I),2,15),PC(I): GOTO 20
      00
```

```
1990  PRINT  MID$ (AM$(I),2,15),P
      C(I),TA(I),TP(I):AG(NN) = TA
      (I):AP(NN) = TP(I)
2000  NEXT I
2010  FOR I = 1 TO 8
2020 NU =  VAL ( MID$ (AD$(I),6,7
      )):SP$ =  MID$ (AD$(I),2,15)

2030  ON AC(I) GOTO 2040,2070,210
      0,2130,2180,2200
2040  REM  TEMP HI-SCALE
2050 TM = NU * 10:TH(NN) = TM
2060  PRINT SP$,TM," DEG. CELCIUS
      ": GOTO 2210
2070  REM  TEMP LO-SCALE
2080 TM = NU * 10 - 40:TL(NN) = T
      M
2090  PRINT SP$,TM," DEG. CELCIUS
      ": GOTO 2210
2100  REM  PRESSURE
2110 PR = NU * 100:RR =  FN DP(PR
       * 1.33):RR(NN) = RR
2120  PRINT SP$,PR;" MMHG",RR;" M
      BAR": GOTO 2210
2130 T1 = 35.61 * NU - 203.67
2140 E2 = 4.48 *  EXP (.0662 * TM
      )
2150 E1 = 4.48 *  EXP (.0662 * T1
      )
2160 RH = (E1 / E2) * 100:RH =  FN
      DP(RH):RH(NN) = RH
2170  PRINT SP$,RH," % REL HUM": GOTO
      2210
2180 TS = 10 * NU - 30:TS(NN) = T
      S
2190  PRINT SP$,TS," DEG. CELCIUS
      ": GOTO 2210
2200  IF I = 8 THEN  PRINT SP$
2210  NEXT I
2220  PRINT "----------------------
      ----------------------------
      --": PRINT
2230  PR# 0
2240  GOTO 1860
2250  END
2260  REM
2270  REM
2280  REM
2290  REM  SUBROUTINE THAT ALLOWS

2300  REM  THE ALPHAMETER CALIBRA
      TION
```

```
2310  REM  PARAMETERS TO BE CHANG
     ED
2320  REM
2330  REM
2340  REM
2350  FOR I = 1 TO NS
2360  HOME : VTAB (10)
2370  PRINT "ALPHAMETER # ";I: PRINT

2380  INPUT "A FACTOR IS (PCI/L/C
     PHR) ? ";A(I)
2390  INPUT "B FACTOR IS (CPHR)
          ? ";B(I)
2400  NEXT I
2410  RETURN
2420  REM
2430  REM
2440  REM
2450  REM  THIS SUBROUTINE ALLOWS

2460  REM  THE USER TO MATCH THE
2470  REM  APPROPRIATE PROBE TO T
     HE
2480  REM  ANALOG DEVICE NUMBER
2490  REM
2500  REM
2510  REM
2520  HOME : VTAB (3)
2530  PRINT "ENTER A FOR TEMP HI-
     SCALE"
2540  PRINT "       B FOR TEMP LO-
     SCALE"
2550  PRINT "       C FOR PRESSURE
     "
2560  PRINT "       D FOR REL. HUM
     IDITY"
2570  PRINT "       E FOR SOIL TEM
     P"
2580  PRINT "       F FOR NO PROBE
     "
2590  VTAB (12): INPUT "WHICH AD
     NO. DO YOU WISH TO CHANGE (1
     -7) ? ";IX
2600  PRINT : INPUT "WHAT PROBE S
     HOULD BE ASSOCIATED WITH THI
     S AD PORT ? ";IX$
2610  IF IX$ = "A" THEN AC(IX) =
     1: GOTO 2670
2620  IF IX$ = "B" THEN AC(IX) =
     2: GOTO 2670
2630  IF IX$ = "C" THEN AC(IX) =
     3: GOTO 2670
```

```
2640  IF IX$ = "D" THEN AC(IX) =
     4: GOTO 2670
2650  IF IX$ = "E" THEN AC(IX) =
     5: GOTO 2670
2660  IF IX$ = "F" THEN AC(IX) =
     6: GOTO 2670
2670  INPUT "DO YOU WISH TO CHANG
     E ANY OTHER AD PORTS (Y) OR
     (N) ? ";Y$
2680  IF Y$ = "Y" THEN  GOTO 2590

2690  RETURN
2700  REM
2710  REM
2720  REM
2730  REM  THIS SUBROUTINE GOES T
     O THE
2740  REM  DISKETTE AND RETRIEVES
      DATA
2750  REM  TO THEN ASSIGN IT TO T
     HE
2760  REM  PROPER VARIABLE
2770  REM
2780  REM
2790  REM
2800 D$ = ""
2810  PRINT D$;"OPEN ALPHALOGGER
     1"
2820  PRINT D$;"READ ALPHALOGGER
     1"
2830  FOR I = 1 TO 3
2840  INPUT E$(I)
2850  IF  MID$ (E$(1),2,4) <  > "
     TIME" AND  MID$ (E$(1),2,11)
      <  > "END OF FILE" AND  MID$
     (E$(1),2,4) <  > "ATIM" THEN
      GOTO 2830
2870  IF  MID$ (E$(I),2,11) = "EN
     D OF FILE" THEN  PRINT "END
     OF FILE": PRINT D$;"CLOSE AL
     PHALOGGER 1": PR# 0: GOSUB 3
     300: GOSUB 3500: END
2880  NEXT I
2890  FOR I = 1 TO NS + 1
2900  INPUT AM$(I)
2910  NEXT I
2920  FOR I = 1 TO 8
2930  INPUT AD$(I)
```

```
2940  NEXT I
2950  RETURN
2960  REM
2970  REM
2980  REM
2990  REM  THIS SUBROUTINE SUMS T
     HE
3000  REM  CPHRS AND PCI/L VALUES

3010  REM  IN ORDER TO CALCULATE
     THE
3020  REM  AVERAGE ON A RECORD BY
      RE-
3030  REM  CORD AS WELL AS ON A T
     OTAL
3040  REM  BASIS
3050  REM
3060  REM
3070  REM
3080 TA = 0:TP = 0
3090 NN = NN + 1
3100  FOR I = 1 TO NS
3110 AM(I) =  VAL ( MID$ (AM$(I),
     7,6))
3120 PC(I) = (AM(I) - B(I)) * A(I
     )
3130 TA = TA + AM(I):TP = TP + PC
     (I)
3140 GA(I) = GA(I) + AM(I)
3150 GP(I) = GP(I) + PC(I)
3160  NEXT I
3170 TA = TA / NS:TP = TP / NS
3180 TA(4) =  FN DP(TA):TP(4) =  FN
     DP(TP)
3190  FOR I = 1 TO NS:PC(I) =  FN
     DP(PC(I)): NEXT I
3200  RETURN
3210  REM
3220  REM
3230  REM
3240  REM  THIS SUBROUTINE PRINTS
      THE
3250  REM  THE TOTAL AVERAGE FOR
     EACH
3260  REM  ALPHAMETER CPHR AND PC
     I/L
3270  REM
3280  REM
3290  REM
```

```
3300  PR# 1: PRINT : PRINT "*****
     ****************************
     ******************": PRINT : PRINT
     "AM NO.","AVG CNT","AVG PCI"
     : PRINT
3310  FOR I = 1 TO NS
3320 CG(I) = GA(I) / NN:PG(I) = G
     P(I) / NN
3330  PRINT I,CG(I),PG(I)
3340  NEXT I
3350  PR# 0
3360  RETURN
3370  REM
3380  REM
3390  REM
3400  REM  THIS SUBROUTINE CREATE
     S
3410  REM  APPLEPLOT COMPATIBLE
3420  REM  FILES FOR CPHRS, PCI/L
     ,
3430  REM  TEMPERATURE, REL HUMID
     ITY,
3440  REM  PRESSURE AND SOIL TEMP
     ERATURE
3450  REM  SO THAT THESE CAN BE P
     LOTTED
3460  REM  AS A FUNCTION OF TIME
3470  REM
3480  REM
3490  REM
3500  HOME : VTAB (10): INPUT "DO
      YOU WANT PLOT FILES CREATED
      ? ";Y$
3510  IF Y$ = "N" THEN  END
3520  HOME : VTAB (10): INPUT "DA
     TA STORED EVERY ONE (1) OR T
     WO (2) HOURS ? ";SS
3530  PRINT D$;"OPEN LOGGER CPHR,
     D2"
3540  PRINT D$;"WRITE LOGGER CPHR
     "
3550  PRINT 100: PRINT 100
3560  FOR I = 1 TO NN STEP SS
3570  PRINT I: PRINT AG(I)
3580  NEXT I
3590  PRINT D$;"CLOSE LOGGER CPHR
     "
3600  PRINT D$;"OPEN LOGGER PCI,D
     2"
```

```
3610  PRINT D$;"WRITE LOGGER PCI"

3620  PRINT 100: PRINT 100
3630  FOR I = 1 TO NN STEP SS
3640  PRINT I: PRINT AP(I)
3650  NEXT I
3660  PRINT D$;"CLOSE LOGGER PCI"

3670  PRINT D$;"OPEN LOGGER TEMP
     HI,D2"
3680  PRINT D$;"WRITE LOGGER TEMP
      HI"
3690  PRINT 100: PRINT 100
3700  FOR I = 1 TO NN STEP SS
3710  PRINT I: PRINT TH(I)
3720  NEXT I
3730  PRINT D$;"CLOSE LOGGER TEMP
      HI"
3740  PRINT D$;"OPEN LOGGER TEMP
     LO,D2"
3750  PRINT D$;"WRITE LOGGER TEMP
      LO"
3760  PRINT 100: PRINT 100
3770  FOR I = 1 TO NN STEP SS
3780  PRINT I: PRINT TL(I)
3790  NEXT I
3800  PRINT D$;"CLOSE LOGGER TEMP
      LO"
3810  PRINT D$;"OPEN LOGGER PRESS
     URE,D2"
3820  PRINT D$;"WRITE LOGGER PRES
     SURE"
3830  PRINT 100: PRINT 100
3840  FOR I = 1 TO NN STEP SS
3850  PRINT I: PRINT RR(I)
3860  NEXT I
3870  PRINT D$;"CLOSE LOGGER PRES
     SURE"
3880  PRINT D$;"OPEN LOGGER RH,D2
     "
3890  PRINT D$;"WRITE LOGGER RH"
3900  PRINT 100: PRINT 100
3910  FOR I = 1 TO NN STEP SS
3920  PRINT I: PRINT RH(I)
3930  NEXT I
3940  PRINT D$;"CLOSE LOGGER RH"
3950  PRINT D$;"OPEN LOGGER SOIL
     TEMP,D2"
```

```
3960  PRINT D$;"WRITE LOGGER SOIL
      TEMP"
3970  PRINT 100: PRINT 100
3980  FOR I = 1 TO NN STEP SS
3990  PRINT I: PRINT TS(I)
4000  NEXT I
4010  PRINT D$;"CLOSE LOGGER SOIL
      TEMP"
4020  RETURN
```

APPENDIX B

LINES FROM-TO	DESCRIPTION
100-350	- Heading.
360-910	- List of variables.
920-1500	- Dimensioning of arrays and vectors. - Input date, sampling place, comment, No. of alphameters, AM calibration factor. - Print AM No., A and B calibration factor. - GOSUB 2350 allows to change A and B factors if desired. - Identify each analog device as a function of AD port number. Default values are given and shown. GOSUB 2520 allows probe assignment to be changed if desired.
1510-1720	- The following are sent to the line printer; date, sampling place, comment, AM No., and calibration factors, AD No. and probe assigned to each number.
1730-1860	- Using GOSUB 2800, one block of data (date, time, cphr, AD voltages and battery pack voltage) is retrieved from sequential data file Alphalogger 1.
1870-1940	- Verify proper date and time format. Print time, date and a blank line as well as some heading on right hand side for following data.
1950-2000	- GOSUB 3080 takes cphr values from AM and converts to pCi/L of radon using A and B factors. Also average value for all AM probes is calculated in cphr and pCi/L. A sum of cphr and pCi/L is kept over all time records to calculate the average of entire study period for each probe. - Print AM No., cphr and pCi/L values for each AM. Also average cphr at that time over all probes. Store average pCi/L and cphr is special arrays to build plotting files later on.
2010-2250	- Depending on which AD probe is concerned, this portion takes the AD data line and operates on it to transform the AD voltage into proper physical units.
2260-2410	- This subroutine is used to input AM calibration factors A and B.
2420-2690	- Subroutine that changes AD probe default assignment.
2700-2950	- This subroutine reads one data block from the sequential data file Alphalogger 1. One data block consists of the time, the date, one blank line, the appropriate number of AMs and associated counts per hour, another blank line, the list of seven analog devices and the battery pack voltage (see Fig. 2). - This portion also checks for odd inputs and END OF FILE markers.
2960-3200	- This subroutine sets up counter NN (keeps track of total number of

data blocks), and sums the cphr and pCi/L values in two different ways. First, over all AM for a given block, and second, over all blocks for every individual AM.

3210-3360 - This subroutine takes the sum over all data blocks calculated in the section immediately above (2960-3200) and divides by NN to get an average over the entire study (pCi/L and cphr) for each AM probe. These are printed also.

3370-4020 - This subroutine is used to create sequential data files compatible with Appleplot Software. The files are stored on a diskette in drive No. 2 where the Appleplot Software is also located.

When the user is asked if he wishes to have the data stored every one or every two hours, he should answer every one hour if the study lasted less than 100 hours (4.1 days) and every two hours if the study was more than 100 hours in duration.